# LABOR-MANAGEMENT AND CODETERMINATION IN REGULATED MONOPOLIES

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# 1. INTRODUCTION

The relationship of labor to the production process has altered
significantly over the past quarter of a century.  Departing from the
classical model of a relatively mobile productive factor which could be
traded in a normal market, organized labor has increasingly pressed for and
obtained long-term contractual arrangements providing relative job security
with seniority and a measure of control over working conditions.  These
changes in labor's role in enterprises have also found their legitimation
in new laws governing employment contracts and employee's rights to par-
ticipate in enterprise decision-making.  Codetermination laws of various
sorts are either in existence or under discussion throughout Europe.[1]  These
laws typically provide for representation of labor on supervisory boards and
institutionalize many traditional trade-union functions in the internal
fabric of enterprise decision-making.

The above trends towards increasing participation of labor in
enterprise policy formation give rise to a number of interesting economic
problems.  Primarily, one would like to know what changes in the behavior
and productivity of firms can be expected when labor codetermines some of the
firm's inputs.  Although these questions have been around for awhile, there is
still little agreement on the answers.  Proponents of labor participation
in enterprise decision-making argue that such participation improves com-
munication between labor and management and provides a reinforcing basis for
broader reaching productivity incentives.  Opponents argue that labor-
management and codetermination interfere with the free functioning of labor
and capital markets and are merely (inefficient) instruments for

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redistributing the gains from productive activity. The problems in resolving this disagreement are the more difficult since a common theoretical framework for analyzing these conflicting claims is lacking. Though we shall delay our discussion of the competing theories on this matter until further below, suffice it for the moment to note that the problem here is to adequately represent the details of the social and economic interaction among firm participants and to integrate these with external market processes. As Leibenstein (1979) points out, developing such a functional "micro-micro" theory is a difficult and open task.

It would, of course, be very useful to have the benefit of empirical research to help sort out these issues, and there has been some progress on this score recently. In an econometric study of West German manufacturing firms, Cable and FitzRoy (1979) have found that labor participation in firm decision-making, especially when coupled with profit-sharing incentives, has a significant positive impact on growth and productivity. Similarly, Freeman and Medoff (1979) find for the U.S. context that unionized firms have demonstrated higher labor productivity (and wages) than their nonunion counterparts. Though preliminary, these empirical results indicate that labor influence in firm decision-making has its positive side. Since this influence is also growing in practice, an analysis of the merits of various forms of labor influence in firm decision-making is of interest. This would seem to be particularly so in monopoly situations, where market forces cannot be expected to sort out the chaff from the wheat. With this in mind, our aim here is to study these issues for a monopoly firm subject to governmental regulation.

It should be clear that any attempt to attribute an active role to labor's interests in the theory of the firm will involve an explicit

treatment of the internal organization of the firm.  Without some care, however, this could easily get out of hand.  We concentrate our attention here on how capital and labor inputs (both the size of the labor force as well as workers' individual inputs) are determined and how these input decisions interact with the incentive schemes linking inputs to the preferences of firm participants.  In this regard, one can imagine a spectrum of possibilities:  pure cases where all inputs and remuneration schemes are set according to the preferences of a profit-maximizer, a welfare-maximizer, or of labor; and mixed cases where a profit-maximizer or a welfare-maximizer determines capital input, and where labor determines all labor inputs (in a noncooperative adjustment process with the capital-manager).  These mixed or codetermined cases may be considered as models of profit-maximizing or welfare-maximizing monopolies in which labor has a dominant influence on employment policies and working conditions.

The next section presents our basic framework, relates this to the problem of  monopoly regulation, and reviews relevant literature.  In the remainder of the paper we then analyze a simple model in more detail, concentrating on capital and labor inputs and their relationship to internal firm adjustment processes and incentives.  For this model, we first consider various unregulated forms of labor-managed, profit-maximizing and codetermined firms, and then we examine how regulation may improve the welfare efficiency of labor-managed and codetermined firms.

## 2.  BASIC DATA AND FRAMEWORK

The classical models of economic regulation (e.g., Bailey [1973]) obviate the necessity of dealing with internal organization by assuming that unanimous (usually profit-maximizing) preferences dictate the behavior of the firm.  If we wish to bring the possible conflicting interests of labor to the fore, we must clearly use a richer model of the firm's organization than this.

Modeling a firm's organization in general would require analysis of a large number of design variables, including authority and incentive structures, information and monitoring systems, technology and personnel.  Here we assume a fixed technology and neglect information and monitoring systems.  The main issue we address is how incentives (in the form of remuneration schemes to firm partici- pants depending on the firm's inputs or outputs) and factor input decisions vary when these are chosen to reflect alternative interests (e.g., of labor, or a profit-maximizing entrepreneur).

We envisage a firm embedded in a competitive economy in which the oppor- tunity costs per unit of capital and labor are $\rho$ and $\hat{W}$ respectively.  The firm has a monopoly in its output market, facing demands $P = P(A,Y)$, where $Y$ is output, $P$ is price and $A$ is a demand-shift parameter, with $\partial P/\partial Y < 0$ and $\partial P/\partial A > 0$.  As to production technology, we assume output specified by $Y = F(K,x,N)$, where $K$ stands for capital goods, $N$ represents the number of workers (with identical preferences as specified below), and $x$ is the input contribution of the typical such worker.  We denote by $Z = (K,x,N)$, the combined input vector.

We illustrate the general framework we have in mind in Figure 1 below.[2] The regulator obtains information $m \in M$ concerning the monopoly's operation and performance.  He then applies a regulatory policy $s(m)$ belonging to some allowable class $S$.  The participants in the monopoly adjust $Z$ in response to $s$, with result- ing output and costs $Y(Z(s))$, $C(Z(s))$.  The nature of this adjustment process depends on whose preferences govern the determination of each of the inputs $(K,x,N)$.  The regulator attempts to maximize a welfare function $W(Y,C,s,m)$ over $S$ and $M$, with $Y$ and $C$ defined at the behavior $Z(s(m))$ resulting from $(s,m)$.  To determine how $Z$ varies under a number of possible regulatory mechanisms, we will need to deal explicitly with the preferences of the agents involved, their internal

adjustment to one another and to the factor market constraints they face in evaluating alternative earning opportunities.
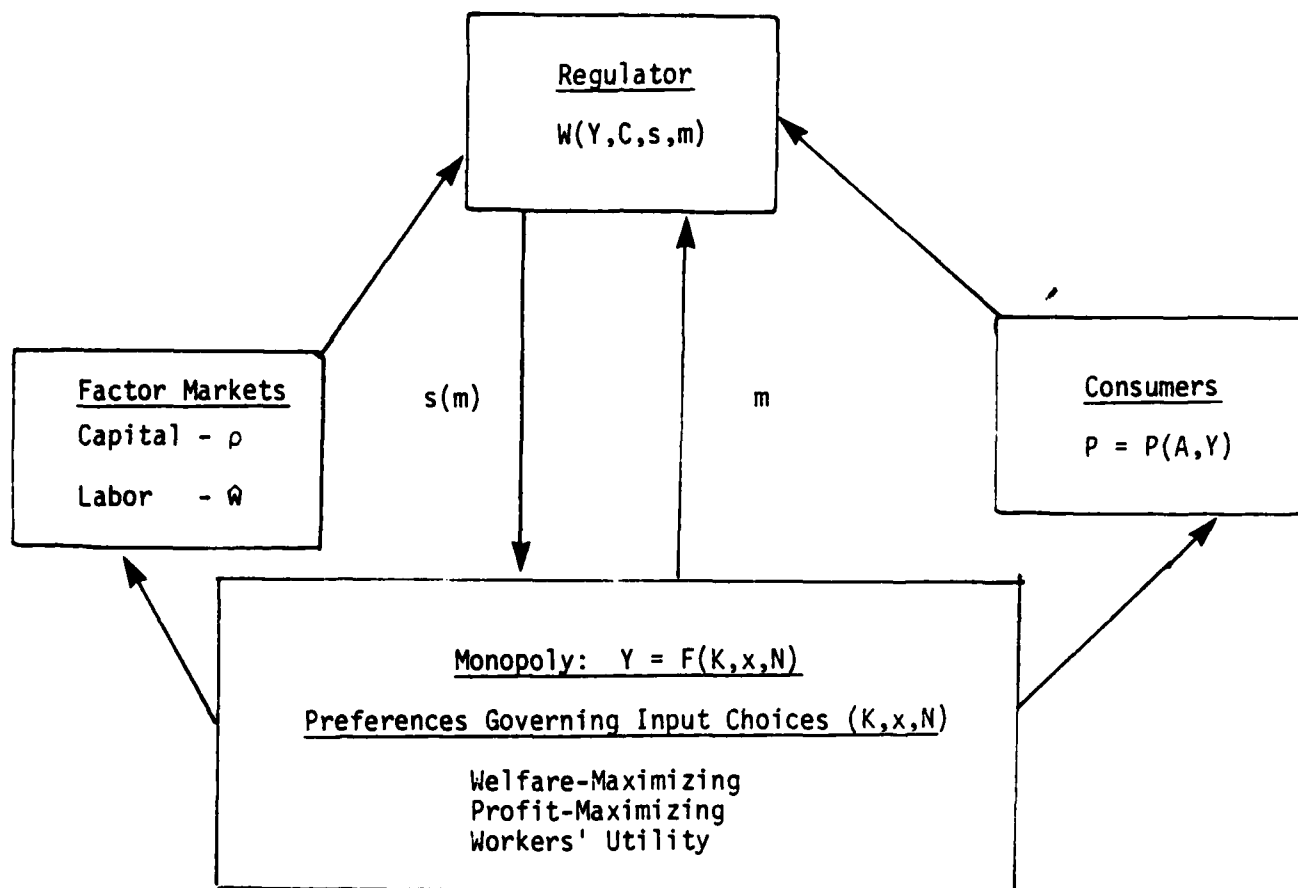
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                        ┌─────────────────┐
                        │    Regulator    │
                        │   W(Y,C,s,m)    │
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┌──────────────────┐                          ┌──────────────────┐
│  Factor Markets  │      s(m)        m       │    Consumers     │
│  Capital - ρ     │                          │   P = P(A,Y)     │
│  Labor   - ω     │                          │                  │
└──────────────────┘                          └──────────────────┘

        ┌──────────────────────────────────────────────┐
        │      Monopoly:  Y = F(K,x,N)                 │
        │  Preferences Governing Input Choices (K,x,N) │
        │          Welfare-Maximizing                  │
        │          Profit-Maximizing                   │
        │          Workers' Utility                    │
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Fig.7.1. The Institutional Set-up

Concerning the N workers in the firm, we assume that each of them exhibits preferences between income r and work x as represented by the utility function

(7.1)                     $U(r,x) = r - E(x)$,

where $E:R^+ \rightarrow R$ is an increasing, strictly convex function with $E(0) = 0$ representing disutility of work, i.e., the value of alternative opportunities (e.g., leisure)

for the typical worker's input. The preferences (7.1) neglect income effects.

We now come to the important matter of incentives, i.e., how firm participants are remunerated for their input contributions. We deal explicitly only with incentives for labor, assuming that whatever other interests are involved receive residual profits after paying labor. Denoting labor's value-added by $V = R - \rho K$ where $R = PY$ is revenue, the two classes of incentive schemes which we consider specify the income r of the typical worker in one of the following ways:

(7.2) $$r = wx \quad \text{or} \quad r = \mu \frac{V}{N} \quad (0 < \mu \leq 1).$$

The former represents the standard wage contract and the latter is value-added sharing.[3] Given these incentives, we obtain the following "effective utility functions" for workers corresponding to (7.2):

(7.3) $$U^W = wx - E(x) \quad \text{or} \quad U^S = \frac{\mu V}{N} - E(x).$$

The external labor market offers workers a wage of $\hat{w}$ per unit of input x. This will operate as a lower bound on what workers will be willing to accept as remuneration for their participation in the firm. Indeed, given $\hat{w}$, workers' utilities in the firm will all have to equal or exceed

(7.4) $$\hat{U} = \max_{x \geq 0} [\hat{w}x - E(x)],$$

in order that they be willing to remain with the firm. For future reference, denote the solution to (7.4) by $\hat{x}(\hat{w})$.

Given the above, we are interested in comparing the welfare consequences resulting from various institutional arrangements for determining and controlling the behavior of the firm. As a measure of total welfare we use the traditional welfare function obtained as the sum of producers' and consumers' surpluses.[4]

In this case, this results in

$$(7.5) \qquad W = \int^{Y} P(z)dz - \rho K - NE(x),$$

where the first term is the sum of consumers' surplus and revenues (which are split between workers' total income and other revenue) and the second and third terms represent the social costs of the firm's inputs.

Returning for just a moment to Figure 1, we may now summarize our intentions as follows. There are three economic agents involved: a welfare-maximizing or profit-maximizing capital manager, a utility-maximizing labor force, and a welfare-maximizing regulator. We first study various forms of unregulated monopoly distinguished by whose preferences, capital, labor, or the regulator, determine the levels of the factors $(K,x,N)$ to be employed. These input decisions are always subject to the market constraints described as well as to the behavioral reactions of participants to the incentives employed. Thereafter we consider what forms of regulatory intervention are likely to improve the performance of the unregulated firms in question.

## 2.1 Labor-Managed and Capitalist-Managed Firms

Given our interest in studying the impact of increased labor participation in firm policy formation, let us briefly review the literature on the polar case of a labor-managed (LM) firm and its comparative performance relative to a capitalist-managed (CM), profit-maximizing firm. The traditional model of the LM firm assumes that each worker-partner of the firm contributes a fixed amount of labor, say $x = \hat{x}$, and, thus, all that need be decided relative to labor input is the size of the labor force.[5] This model therefore amounts to maximizing $U^S$ in (7.3) over feasible K and N with $x = \hat{x}$ fixed. The model of the CM firm

with which the above LM firm is typically compared assumes the same fixed labor input per worker $\hat{x}$ (which is purchased at the competitive rate $\hat{w}$). The CM firm then maximizes the profit $\Pi = V - N\hat{w}\hat{x}$ over N and K.

Comparing the LM and CM firm, the basic results are the following.[6] <u>In the short run</u> (no capital adjustment), the LM firm will employ less labor with a given stock of capital (and hence produce less) than its CM counterpart. Moreover, the LM firm will adjust output downwards with an elasticity-preserving increase in demand or a reduction in the financial charges on fixed financial debts of the firm. <u>In the long run</u>, the LM firm will have a smaller output and its perverse downward adjustment of output in reaction to demand increases and factor price decreases may persist.

These results present a rather disturbing picture of the LM firm. Several criticisms have been raised concerning their general validity, however. First, the standard assumption that the level of input x per worker will remain unchanged between CM and LM firms is suspect. Second, there is a problem with the assumption that the LM firm can adjust its personnel (N) at will.[7] To clarify the issues here, let us briefly analyze the LM and CM firm in terms of the above presystem.

We may represent the LM firm as solving

$$(7.6) \qquad \text{Maximize} \quad \left[ \frac{R - \rho K}{N} - E(x) \right],$$

i.e., the typical worker-partner's utility is maximized using value-added sharing in (7.3) with $\mu = 1$.[8] We assume that the solution to (7.6) entails $U \geq \hat{U}$ in (7.4), since otherwise no feasible solution for the LM firm (and, <u>a fortiori</u>, for the CM firm described below) would exist.

Now consider the CM firm and suppose it sets the wage rate at w. Then

maximation of $U^W$ in (7.3) implies that x will be chosen by workers so that $E'(x) = w$, where $E'(x) = dE/dx$. Thus, the CM firm may be represented as solving[9]

(7.7)                          Maximize $[R - \rho K - NE'(x)x]$

subject to:

(7.8)                                    $E'(x) \geq \hat{w}$

where (7.8) assures that the CM firm pays at least the competitive wage rate. If R (equivalently F) depends on (N,x) only through the aggregate L = Nx, then substituting $w = E'(x)$ in (7.7)-(7.8) we see that profit also depends on (N,x) through L. In this case, the CM firm would always increase L by increasing N rather than exceed $\hat{w}$. For the general case treated here, however, it may be optimal for the CM firm to set $w > \hat{w}$ when $\hat{w}$ is low and the marginal revenue-product of x is high relative to that of N.

It is instructive to compare the LM and CM firms in two stages. First, fix N. Then, from (7.6), the LM firm may be viewed as deterining K and x by maximizing $NU(K,x,N) = R - \rho k - NE$. Comparing this with (7.7), we see that the CM firm maximizes $R - \rho k - N\bar{E}$, where $\bar{E}(x) = x E'(x) > E(x)$ because of the strict convexity and monotonicity of E. Thus, in effect, the CM firm pays a higher cost per unit of effort than the LM firm. This leads to the CM firm's employing less labor input and, if $R_{Kx} > 0$, less capital. From this it follows that, when the composition of the work force is fixed, the LM firm is superior to the CM firm in terms of welfare, output, revenue, and, of course, workers' utilities.[10]

The superiority of the LM firm over the CM firm does not persist when we allow N to be freely adjusted. But there are several competing views on this subject. First, one can assume that the LM firm determines N directly through

the solution to (7.6). Comparing this "pure" LM firm to the CM firm represented by (7.7) leads to the conclusion that the LM firm has a tendency to hire or retain too few worker-owners in order to spread the benefits of membership among a smaller set of recipients.[11] Indeed, as we shall see below, this tendency can be strong enough to cancel the gains from improved labor incentives in the LM firm and to make the CM firm welfare-superior to it. Moreover, if N is adjusted in the short-run for the LM firm, then the perverse responses to demand shifts noted above will also result.

A second approach to how the LM firm may adjust its employment level has been suggested by Sertel (1978),[12] who proposed that since workers are better off in the LM firm than in the general labor market, workers would be willing to pay an entry fee in order to join the LM firm. By equating this fee to the additional utility available to them in the LM firm, one obtains a supply curve of workers for the LM firm which, as in Domar (1966), is upward sloping. The demand curve for workers is obtained by equating the entrance (or severance) fee to the compensation required to balance the net decrease (or increase) in utility of existing worker-partners if an additional worker joins (leaves) the LM firm. At the equilibrium entrance fee, the LM firm behaves exactly as the CM firm.

A final point of importance in the LM firm context is the dynamic behavior of the firm with respect to capital adjustments. Several authors[13] have shown the pure LM firm is likely to require a higher rate of return on investment projects than the (efficient) capital market would dictate if workers' time horizons for appropriating the benefits of such investments are shorter than that in the market. Now, if one allows shares in the firm to be traded in the normal way, this difficulty disappears.[14] Nonetheless, some caution seems advisable in dealing with the capital input decision. For this reason, and also for its own

sake, we consider below the institutional structure which we call codetermination, in which a capital-manager, appointed by the state, makes the capital input decision, attempting to maximize either welfare or profits in the process, while labor chooses all labor inputs.

Summarizing our comparison of LM and CM firms, the following picture emerges. The LM firm provides desirable incentives for increased labor productivity, but possibly at the expense of inefficient levels of employment and investment. From the point of view of regulation of monopolies with strong labor influence on policy formation, therefore, the key matter of interest is to counteract these possible negative effects of labor participation through appropriate regulatory instruments.

## 2.2 Regulation of Labor-Influenced Monopolies

With specific reference to our main interest, the LM firm and its variants, the following considerations seem important in determining appropriate regulatory mechanisms. First, the typical worker's input, x, is likely to be unobservable. Regulatory mechanisms will thus depend on x only through observable quantities like output, income per worker, or capital assets. The inability to observe and regulate x is a matter of some importance, as we shall see. Indeed, neglect of this aspect of the LM firm makes much of the previous literature on LM firms of dubious relevance. For the interaction of incentives and productivity in response to regulation on labor only become clear when we explicitly consider their impact on both average productivity and total employment, especially when labor is strongly affecting the level of both of these as in the LM firm.

Second, how regulation should be accomplished depends on how the LM firm would adjust its employment level in the absence of regulation. If entry and

severence fees can be institutionalized, then, as pointed out, the LM firm will tend to behave like a CM firm, and should be regulated as such. Gal-or et al. (1978) consider this case in detail and we will not consider it further here.[15]

If entry fees are not used, then the LM firm will act quite differently than a CM firm, and it is an open question as to what regulatory instruments are likely to be of value. The only discussions of this case in the literature appear to be Meade (1974) and Steinherr and Vanek (1976). The later propose output price ceilings and a lump-sum tax fixed to equalize marginal returns to factors in the competitive and monopolistic sectors. Lump-sum taxes can be expected to improve efficiency by encouraging the LM firm to increase N so as to spread the tax burden. Price regulation is, of course, directed at restricting the monopoly power of the firm. However, there are several problems with it as we discuss in section 4 below. A further class of regulatory policies studies is directed at increasing output by restricting workers' incomes via constraints which vary with output.

## 3. UNREGULATED LABOR-MANAGED AND CODETERMINED FIRMS

In this section and the next we compare, for a special case of the above model, five types of firm. These are summarized in Table 7.1. For each firm type we specify whose preferences determine the setting of each input and of the parameters of labor incentives ($\mu$ or w in (7.2)). When these preferences governing different inputs are in conflict, we evaluate the outcome at the equilibrium of the resulting noncooperative game.

Note also the following concerning Table 7.1. For the WM firm we disregard distributional and incentive matters and determine all inputs in a first-best manner. For the LM firm we study only sharing incentives as these are

TABLE 7.1

SUMMARY OF CASES STUDIED

| | Objectives* Governing the Setting of | | | | |
| | Inputs | | | Incentives | |
| Firm Type | K | x | N | $r = wx$ | $r = \mu\dfrac{V}{N}$ |
|---|---|---|---|---|---|
| Welfare-Maximizing (WM) | W | W | W | (a) | (a) |
| Labor-Managed (LM) | U | U | U | (b) | W |
| Capitalist-Managed (CM) | Π | U | Π | Π | (c) |
| Codetermined Welfare-Maximizing (COWM) | W | U | U | (b) | W |
| Coedtermined Profit-Maximizing (COPM) | Π | U | U | Π | Π |

*W = Welfare, Π = Profit, U = Typical Worker's Utility

(a) Incentives not considered in the WM firm.

(b) Wage incentives not studied in the LM and COWM firms.

(c) Sharing incentives not studied in the CM firm.

equivalent to wage incentives in the LM firm (see footnote 8). For the CM firm we neglect sharing incentives since a profit-maximizing designer would eschew these anyway (see footnote 9). For the COPM firm, we discuss both wage and sharing incentives. Finally, as explained prior to (7.8)-(7.9), one may think of the CM firm as determining either w or x as they are uniquely related through w = E'(x).

Henceforth, we consider a special case of the model developed in section 2. We assume workers' utility functions (7.1) specified by

$$(7.9) \qquad U(x,r) = r - E(x) = r - Cx^\gamma$$

with C>0, $\gamma$>1, and r = w x (wage incentives) or $\tau = \mu V/N$ (sharing incentives). The production technology specifies output as

$$(7.10) \qquad Y = K^\alpha x^\beta e(N) \qquad (0<\alpha,\beta; \ \alpha<1, \ \beta\leq1),$$

where the function e(N) is defined below. We assume demand to be of the constant elasticity form

$$(7.11) \qquad P(Y) = AY^{-\frac{1}{\epsilon}} \qquad (A>0, \ \epsilon>1).$$

From this, we obtain the revenue function

$$(7.12) \qquad R = PY = AK^a x^b f(N),$$

where

$$(7.13) \qquad a = \alpha(1 - \frac{1}{\epsilon}), \ b = \beta(1 - \frac{1}{\epsilon}), \ f(N) = e(N)^{1-\frac{1}{\epsilon}}.$$

We further assume that economies of scale (as measured by $\alpha + \beta - 1$) are sufficiently small so that $a + \frac{b}{\gamma} < \alpha + \frac{b}{\gamma} < 1$.

We assume the function $f:R^+ \to R$ is twice differentiable and satisfies the following properties:

(i) $f(0) = 0$, $f(N) \geq 0$ ($N \geq 0$);

(ii) For any $t\epsilon[1/(1-a), \gamma/b]$ the equation

(7.14)
$$\frac{f(N)}{N} = tf'(N)$$

has a unique solution $N(t)$. Moreover, $f(N)/N$ intersects $tf'(N)$ from below at $N = N(t)$.

The properties of the function $e:R^+ \to R$ follow from those for f through (7.13). An example of a class of functions satisfying (i)-(ii) above is[16]

(7.15)
$$f(N) = c_1 N^{c_2} - c_3 N^{c_4} \quad (c_1,c_3>0, \ c_4 \geq 1, \ 0<1-a<c_2<c_4).$$

Turning to the five firms of interest, the WM, LM and COWM firms can be handled in symmetric fashion, and the next three subsections develop first-order conditions for these cases, which we then solve in general and compare in section 3.4. Thereafter we consider the CM firm and the COPM firm and compare these with previous cases.

### 3.1 The Welfare-Maximizing (WM) Firm

For this model the welfare function (7.5) is of the form

(7.16)
$$W = \int^Y P(z)dz - \rho K - NCx^\gamma.$$

The first-order conditions for maximizing W are, for N,x and K, respectively

$$(7.17) \qquad Re'(N) = e(N)Cx^\gamma,$$

$$(7.18)_x \qquad \beta R = \gamma NCx^\gamma,$$

$$(7.18)_K \qquad \alpha R = \rho K.$$

Moreover, using (7.13) and (7.18), we may rewrite (7.17) as

$$(7.18)_N \qquad \frac{f(N)}{N} = \frac{\gamma}{b} f'(N),$$

which, since $1 - \alpha - \frac{b}{\gamma} > 1 - \alpha - \frac{\beta}{\gamma} > 0$, has a unique solution from (7.14).

## 3.2 The LM Firm

For the LM firm labor selects all inputs ($x,N$ and $K$) so as to maximize $U(x,r)$ in (7.9) with $r = \mu V/N$. We assume that labor's share $\mu \in (0,1]$. Using (7.12), (7.9) can be written

$$(7.19) \qquad U = \frac{\mu A K^a x^b f(N) - \rho K}{N} - Cx^\gamma.$$

This leads to the following first-order conditions for $N, x$ and $K$ respectively:

$$(7.20) \qquad \frac{R - \rho K}{N} = \frac{Rf'(N)}{f(N)}$$

$$(7.21)_x \qquad \mu bR = \gamma NCx^\gamma$$

$$(7.21)_K \qquad aR = \rho K.$$

From (7.20) and (7.21), we obtain

$$(7.21)_N \qquad \frac{f(N)}{N} = \frac{f'(N)}{1-a},$$

which, by our assumptions on f, uniquely determines N.

## 3.3 The Codetermined Welfare-Maximizing (COWM) Firm

Let us now consider the codetermined case where a welfare-maximizing capital manager sets K and labor maximizes (7.19), taking K as given. Labor's solution for N and x leads immediately to the first-order conditions (7.17)-(7.18)$_x$. The capital manager takes N and x as set by labor and determines K by maximizing W in (7.16). (We assume, unless otherwise noted, that workers' utility exceeds the competitive level, (7.4).) The first-order condition for the capital manager is then $PY_K = \rho$ which from (7.10)-(7.12) becomes

$$(7.22)_K \qquad\qquad \alpha R = \rho K.$$

Using this with (7.17)-(7.18) we obtain as before the following conditions for x and N:

$$(7.22)_x \qquad\qquad \mu b R = \gamma N C x^\gamma;$$

$$(7.22)_N \qquad\qquad \frac{f(N)}{N} = \frac{f'(N)}{1-\alpha};$$

which constitute the first-order conditions for this case.

## 3.4 Comparative Results

We now summarize and compare the WM, COWM, and LM firms. We denote solution values for these firms by an overbar, underbar, and overdot respectively (see Table 7.2). From (7.18), (7.21) and (7.22) the first-order conditions for the WM, COWM, and LM firms are all of the form.

$(7.23)_x$ 

$$qR = NCx^{\gamma};$$

$(7.23)_K$ 

$$sR = K;$$

$(7.23)_N$ 

$$\frac{f(N)}{N} = tf'(N);$$

where the parameters q,s,t, are given in Table 7.2 below.

TABLE 7.2

PARAMETER VALUES FOR (7.23)

| | Notation for Solution Values | q | s | t |
|---|---|---|---|---|
| Welfare-Maximizing (WM) Firm | $\overline{W},\overline{Y},\overline{K},\ldots$ | $\frac{\beta}{\gamma}$ | $\frac{\alpha}{\rho}$ | $\frac{\gamma}{b}$ |
| Codetermined (COWM) Firm | $\underline{W},\underline{Y},\underline{K},\ldots$ | $\frac{\mu b}{\gamma}$ | $\frac{\alpha}{\rho}$ | $\frac{1}{1-\alpha}$ |
| LM Firm | $\dot{W},\dot{Y},\dot{K},\ldots$ | $\frac{b}{\gamma}$ | $\frac{a}{\rho}$ | $\frac{1}{1-a}$ |

Solving (7.23) is straightforward. $N = N(t)$ is determined uniquely from $(7.23)_N$ by assumption (see (7.14)). Also (7.12) may be used with (7.23) to solve for $R = R(q,s,t)$ as

$(7.24)$

$$R(q,s,t) = \left[ \left( s^a Af(N(t)) \right)^{\gamma} \left( \frac{q}{CN(t)} \right)^b \right]^{\frac{1}{\gamma(1-a)-b}}.$$

From this and (7.23), we also obtain Y,W,U,x,K and r as functions of q,s,t. In particular, from (7.11)-(7.12),

$(7.25)$

$$Y = \left( \frac{R(q,s,t)}{A} \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

and, from (7.10) and (7.16),

$$(7.26) \qquad W = \left( \frac{\varepsilon}{\varepsilon-1} - \rho s - q \right) R(q,s,t),$$

since the surplus integral in (7.16) is just $\varepsilon R/(\varepsilon-1)$.

Turning to comparative results, first note that $\beta > \mu b$, $\alpha > a$, and $1-\alpha > \frac{b}{\gamma}$, so that the values for q,s and t are all nonincreasing in each column in Table 7.2. From this, analysis of the comparative statics of the system (7.23) can establish the relative magnitudes of quantities of interest. For example, totally differentiating $(7.23)_N$, the solution $N(t)$ to $(7.23)_N$ satisfies

$$(7.27) \qquad \frac{dN(t)}{dt} = \frac{Nf'(N)}{(f'(N)(1-t)-tNf''(N))},$$

which, for $t \geq 1/(1-a)$, is positive since $tf'(N) = f(N)/N > 0$ and since the denominator in (7.27) is just the negative of the derivative of $tf'(N) - f(N)/N$ evaluated at $N = N(t)$, and this derivative is negative by our assumptions on $f(N)$. Thus, $dN(t)/dt > 0$ and, from Table 7.2, $\overline{N} > \underline{N} > \dot{N}$.

It is straightforward, but rather tedious, to determine the relative magnitudes of other quantities of interest. The results of this analysis are in Table 7.3.

TABLE 7.3

COMPARATIVE RESULTS

| Firm Type | Relative Rank of Given Quantities* | | |
| --- | --- | --- | --- |
| | W,R,Y,K,N | U | x,r |
| WM | Highest | Lowest | Indeterminate |
| COWM | Middle | Middle | Indeterminate |
| LM | Lowest | Highest | Indeterminate |

*$U = \mu\frac{V}{N} - E(x)$ is understood to be evaluated at a common $\mu \in (0,1)$ across firm types.

Thus, in going from the LM firm to the COWM firm to the WM firm, welfare, revenue, output, size of work force, and capital input all increase, and workers' utilities all decrease. Workers' inputs and incomes may be smaller or larger, however, between any two of the firm types considered.[17]

Two remaining points are of interest. First, it can be verified from (7.23)-(7.25) that, in all three cases considered, x,K,R and Y are increasing functions of the demand shift parameter A. Thus, in the long-run, these firms all adjust output upwards as demand increases. The usual "perverse" behavior of the LM firm persists in the short-run, however, in that with fixed capital the LM firm will lower output and employment in response to a positive shift in demand. The COWM firm also has this problem.

Finally, for both the LM and codetermined firms, lowering $\mu$ (e.g., by imposing a wage tax at the rate $(1-\mu)$) reduces outputs and welfare. This is evident from Table 7.3 and (7.24)-(7.25) for output, since t and s are unaffected by $\mu$ and q is an increasing function of $\mu$. For welfare, we have from Table 7.3 and (7.26) for the LM and COWM firms:

$$(7.27) \qquad W = H\left(\frac{\varepsilon}{\varepsilon-1} - \rho t - \frac{\mu b}{\gamma}\right)\mu^{\frac{b}{\gamma(1-a)-b}}$$

where H>0 does not depend on $\mu$. From this, one computes $\partial W/\partial \mu > 0$. Thus, $\mu=1$ is optimal for the LM and COWM firms, i.e., no tax.

## 3.5 The CM Firm

We assume the model of the CM firm given in (7.7)-(7.8). A profit-maximizing agent sets capital, employment level and the wage rate, at or above the competitive level. He does this knowing the disutility of effort function $E(x)$, so that $E'(x) = w$ is the assumed response of labor to wage w (see footnote 9).

Substituting $E'(x) = \gamma C x^{\gamma-1}$ in (7.7)-(7.8), we obtain the first order conditions for the CM firm from maximizing the Lagrangean

(7.28)
$$L = R - \rho K - \gamma N C x^\gamma + \lambda(\gamma C x^{\gamma-1} - \hat{w}),$$

with R as in (7.12). This yields

(7.29)$_x$
$$bR = \gamma^2 N C x^\gamma - \lambda\gamma(\gamma-1)Cx^{\gamma-1},$$

(7.29)$_N$
$$R = \gamma C x^\gamma \frac{f(N)}{f'(N)},$$

(7.29)$_k$
$$aR = \rho K,$$

with $\lambda(C\gamma x^{\gamma-1}-\hat{w})=0$, $\lambda\geq 0$, where $\lambda$ is the Lagrange multiplier associated with (7.8). Let us denote solution values to (7.29) by $\ddot{x},\ddot{N},\ddot{K}$.

Now assume the competitive wage rate $\hat{w}$ is not so high that the CM firm cannot earn nonnegative profits, so that, at optimum, we have from (7.29)

(7.30)
$$0 \leq \pi = R - \rho K - NxE'(x) = R(1-a) - N\frac{Rf'(N)}{f(N)},$$

or, cancelling R,

(7.31)
$$\frac{f(N)}{N} \geq \frac{f'(N)}{1-a}.$$

From this and (7.21)$_N$, $\ddot{N}\geq\dot{N}$ since $f(N)/N$ intersects $f'(N)/(1-a)$ from below at $\dot{N}$ (and remains above $f'(N)/(1-a)$ for $N\geq\dot{N}$, since $\dot{N}$ is the unique solution to (7.21)$_N$). Thus, if $\Pi\geq 0$ at optimum, then $\ddot{N}\geq\dot{N}$, with $\ddot{N}>\dot{N}$ if $\Pi>0$.

To solve (7.29) one proceeds for two cases, $\lambda=0$ and $\lambda>0$. When $\lambda=0$, the wage constraint is not binding and (7.29) reduces to the form (7.23) with $q = b/\gamma^2$, $s = a/\rho$ and $t = \gamma/b$, so that the case $\lambda=0$ is easily solved. In particular, when

$\lambda=0$ $(\ddot{w} > \hat{w})$, $\ddot{N} = \overline{N}$, the WM solution, since $\overline{N}$ solves $(7.23)_N$ uniquely for $t = \gamma/b$.

When $\lambda>0$, the wage constraint is binding, so that $(7.29)_x$ can be replaced by $E'(x) = C\gamma x^{\gamma-1} = \hat{w}$, i.e.,

$$(7.32) \qquad \ddot{x} = \hat{x} = \left(\frac{\hat{w}}{C\gamma}\right)^{\frac{1}{\gamma-1}}.$$

N and K can then be computed from $(7.29)_{N,K}$.

To determine whether $\lambda=0$ or $\lambda>0$, one compares the value of workers' utility $\ddot{U}_0$ obtained assuming $\lambda=0$ with $\hat{U}=\hat{w}\hat{x}-E(\hat{x})$ in (7.4). If $\ddot{U}>\ddot{U}_0$, then $\lambda>0$ since the solution to (7.29) with $\lambda=0$ always entails larger profits than the solution for $\lambda>0$ (the latter corresponding to a constrained solution). Otherwise $(\ddot{U}_0\leq\hat{U})$, $\lambda=0$ and $\ddot{w}>\hat{w}$. Carrying this through, we find that the CM firm pays above competitive wages whenever $\hat{w}$ is small, the elasticity of output $\beta$ with respect to worker effort is large, demand is large, or the cost of capital is small. The precise conditions for $\ddot{w}>\hat{w}$ to obtain may be stated in terms of the following function $g:R^+\to R^+$,

$$(7.33) \qquad g(\hat{w}) = \frac{\hat{w}^{\frac{\gamma(1-a)-b}{\gamma-1}}\left(\frac{\rho}{a}\right)^a}{A(C\gamma)^{\frac{1-a-b}{\gamma-1}}} - .$$

The cases $\ddot{w}=\hat{w}$ and $\ddot{w}>\hat{w}$ are characterized as follows. If $f'(\overline{N})^{1-a}f(\overline{N})^a>g(\hat{w})$, then $\ddot{N}=\overline{N}$ and the CM firm pays workers above the competitive wage; and if $f'(\overline{N})^{1-a}f(\overline{N})^a \leq g(\hat{w})$ then the competitive wage obtains, $\dot{N}\leq\ddot{N}\leq\overline{N}$, and $\ddot{N}$ is determined by

$$(7.34) \qquad f'(\ddot{N})^{1-a}f(\ddot{N})^a = g(\hat{w}),$$

with $\partial N/\partial \hat{w} \leq 0$.

With $\ddot{N}$ and $\ddot{w}$ determined as above, $\ddot{x}$ and $\ddot{K}$ are easily obtained from $E'(\ddot{x}) = \ddot{w}$ and $(7.29)_K$. The complete solution for the CM firm is given in Table 7.4. Though not obvious from Table 7.4, it is the case[18] that as $\hat{w}$ increases beyond the point where (7.8) becomes an effective constraint for the CM firm, welfare, profit, revenue, output, capital and size of workforce all decrease, while workers' inputs, incomes and utilities all increase. In short, the CM firm studied here behaves normally. Comparison of the CM firm with other cases of interest will be discussed in section 3.7 below.

### 3.6  The  Codetermined Profit-Maximizing (COPM) Firm

We continue to assume that capital input and labor incentives are set by a profit-maximizer, but we now assume that both N and x are determined by labor. We consider both wage and sharing incentives for the COPM firm. We first observe that if wage incentives are used (see (7.3)), then labor will have no interest in determining N unless they perceive the wage level to be a function of N. In Kleindorfor and Sertel (1979c) we develop a codetermination model assuming that the wage level and all inputs are set so that the total payroll, Nwx, does not exceed a fixed share $\mu$ of labor's value-added, i.e.,

$$(7.35) \qquad\qquad Nwx \leq \mu(R-\rho K).$$

One can then solve (7.7) subject to (7.8) and (7.35) for the profit-maximizing capital and wage rate, assuming N fixed by labor. From this, N is determined so as to maximize the typical worker's utility along the profit-maximizer's response curve to a given N. The reader will be spared the derivation of this. Here we note only the main results.

TABLE 7.4

THE PROFIT-MAXIMIZING (CM) CASE

| | The case $\ddot{w} > \hat{w}$ obtains when[1] $f'(\bar{N})^{1-a} f(\bar{N})^a > g(\hat{w})$ | The case $\ddot{w} = \hat{w}$ obtains when[1] $f'(\bar{N})^{1-a} f(\bar{N})^a \leq g(\hat{w})$ |
|---|---|---|
| Revenue R | $\ddot{R} = \left(\dfrac{\rho}{a}\right)\overline{\left[\left(\dfrac{aA}{\rho}\right)^{\gamma-b}\left(\dfrac{bA}{\gamma^2 C\ddot{N}}\right)^b f(\ddot{N})^\gamma\right]}^{\frac{1}{\gamma(1-a)-b}}$ | $R = \hat{w}\left(\dfrac{\hat{w}}{C\gamma}\right)^{\frac{1}{\gamma-1}}\dfrac{f(\ddot{N})}{f'(\ddot{N})}$ |
| Welfare W | $\ddot{W} = \left(\dfrac{\epsilon}{\epsilon-1} - a - \dfrac{b}{\gamma^2}\right)\ddot{R}$ | $W = \left(\dfrac{\epsilon}{\epsilon-1} - a - \dfrac{\ddot{N}f'(\ddot{N})}{f(N)}\right)\ddot{R}$ |
| Output Y | $\ddot{Y} = \left(\dfrac{\ddot{R}}{A}\right)^{\frac{\epsilon}{\epsilon-1}}$ | $\ddot{Y} = \left(\dfrac{\ddot{R}}{A}\right)^{\frac{\epsilon}{\epsilon-1}}$ |
| Capital Input K | $\ddot{K} = \dfrac{a}{\rho}\ddot{R}$ | $\ddot{K} = \dfrac{a}{\rho}\ddot{R}$ |
| Typical Worker's Utility U | $\ddot{U} = \dfrac{b(\gamma-1)}{\gamma^2}\dfrac{\ddot{R}}{\ddot{N}}$ | $\ddot{U} = \hat{U} = C(\gamma-1)\left(\dfrac{\hat{w}}{C}\right)^{\frac{\gamma}{\gamma-1}}$ |
| Typical Worker's Input x | $\ddot{x} = \left(\dfrac{b\ddot{R}}{\gamma^2 C}\right)^{\frac{1}{\gamma}}$ | $\ddot{x} = \hat{x} = \left(\dfrac{\hat{w}}{C\gamma}\right)^{\frac{1}{\gamma-1}}$ |
| Typical Worker's Income | $\ddot{r} = \dfrac{b\ddot{R}}{\gamma\ddot{N}}$ | $\ddot{r} = \hat{w}\hat{x} = C\left(\dfrac{\hat{w}}{C\gamma}\right)^{\frac{\gamma}{\gamma-1}}$ |
| Size of Workforce N | $\ddot{N} = \bar{N}$ | $\dot{N} \leq \ddot{N} < \bar{N}$ |

[1]The function $g(\hat{w})$ is given by (7.33). Double dots above a variable indicate valuation at the CM firm optimum.

For the above model we find that the essential difference between the CM firm and the COPM firm is that the latter will have a lower employment level than the former. This also leads to a reduction in output and welfare vis à vis the CM firm, although worker's utilities may increase. For example, if $\hat{w}$ is sufficiently low and $\mu$ in (7.35) is greater than $b/\gamma(1-a)$, the solution to the COPM firm is given by column 1 of Table 7.4 with the LM solution $\mathring{N}$ substituted everywhere for $\ddot{N}$. This is inferior to the corresponding CM solution from everyone's point of view except labor.

Another formulation of the coedetermined firm would be to remunerate labor (who set N and x) by a sharing system, with the typical worker receiving $r = \mu(R-\rho k)/N$ and the profit-maximizing capitalist (who sets K and possible $\mu$) receiving the residual $\Pi = (1-\mu)(R-\rho K)$. When the capital manager and labor adjust noncooperatively in this case, with labor maximizing (7.19) and the capital manager maximizing $\Pi$, the equilibrium conditions (7.21) result. Thus, this form of codetermination using value-added sharing duplicates the LM firm.[19]

From the above we can see that the interesting comparisons for our model are between the CM firm, the LM firm, and the COWM firm. The COPM firms discussed are either inferior or identical to one of these.

## 3.7. Comparing the CM Firm with Other Firms

We first observe that, for any wage rate for which the CM firm can earn nonnegative profits, the LM firm always provides its members with a utility exceeding the competitive level. To see this note that the LM and CM solutions satisfy

$$(7.35) \qquad \mathring{U} = \text{Max} \left[ \frac{R-\rho K}{N} - E(x) \right] \geq \frac{\ddot{R}-\rho \ddot{K}}{\ddot{N}} - E(\ddot{x}),$$

so that, assuming nonnegative profits, $\ddot{R}-\rho\ddot{K}\geq\ddot{N}\ddot{x}E'(\ddot{x})$, the CM firm's wage costs.

Thus, since $\ddot{U}=\ddot{x}E'(\ddot{x})-E(\ddot{x})\geq\hat{U}$ by (7.8) for the CM firm, we see that (7.35) implies $\dot{U}\geq\hat{U}$. The constraint $\dot{U}\geq\hat{U}$ may therefore be safely disregarded in comparing the LM and CM firms.

As noted in section 3.5, as $\hat{w}$ increases beyond the point where it becomes a constraint for the CM firm, welfare, profit and output all decrease in this firm, while workers' utilities increase. We thus concentrate our comparisons of the LM and CM firms on this case where the competitive wage constraints is not binding. This is the best case for the CM firm.

For this unconstrained case, we verify in Kleindorfer and Sertel (1979c) that as demand elasticity $\varepsilon$ approaches unity the CM firm dominates the LM firm in size, output, revenue, welfare and capital input. The converse holds by $b/\gamma$ is sufficiently close to 1-a, i.e., when the elasticity of average input per worker $\beta$ is large and the disutility of work $E(x) = Cx^\gamma$ has low elasticity. Moreover, given the above noted negative effects of increases in the competitive wage on the CM firm, one would expect it to be increasingly inefficient relative to the LM firm as the competitive wage level becomes large. Finally, as noted in section 2, for any fixed N, the LM firm is welfare-superior to the CM firm for this model (where $R_{Kx}>0$).

Although a detailed comparison of the CM and COWM firm is beyond the scope of this paper, the results of section 3.4 show that the COWM firm dominates the CM firm whenever the LM firm does, and in particular when demand elasticity or the competitive wage rate are high. However, as in the LM firm, the COWM firm may be inferior to the CM firm when demand is inelastic. To see this, note from (7.24), Table 7.3 and Table 7.4 (first column) that

$$(7.36) \qquad \left(\frac{\ddot{R}}{\underline{R}}\right)^{\gamma(1-a)-b} = \left(\frac{a}{\alpha}\right)^{a\gamma} \left(\frac{N}{\gamma\bar{N}}\right)^{b} \left(\frac{f(\bar{N})}{f(\underline{N})}\right)^{\gamma}.$$

Now, if we assume $\bar{N}$ is bounded,[20] than as $\epsilon{\to}1$, $a{\to}0$, $b{\to}0$, and the first two terms on the rhs of (7.36) go to unity, since $\underline{N}$ does not depend on $\epsilon$ (see $(7.22)_N$). Thus, since $f(\bar{N}){>}f(\underline{N})$, we see that $\ddot{R}{>}\underline{R}$ as $\epsilon{\to}1$. From this it is an easy process to verify that welfare and output are also higher in the CM firm than in the COWM firm as $\epsilon{\to}1$. The precise domains of superiority of the CM and COWM firms remain an open question.

## 4. REGULATION OF LABOR-MANAGED MONOPOLIES

Let us now consider the various forms of regulation introduced in section 2.2 within the context of the special case studied in the previous section. Given the extensive literature on the regulation of the CM firm, and for reasons of space, we concentrate here on the LM and COWM firms, including the COPM firm with sharing incentives as a special case of the LM firm. We first consider various forms of income regulation and then we turn to price and tax regulation.[21] We will present these results in the context of the COWM firm, indicating parallel developments for the LM case as we go.

### 4.1 Income Regulation

Income regulation is accomplished by appending constraints, on either the typical worker's income or on total labor income, to labor's problem of maximizing U in (7.19). However, if such constraints are to improve the performance of the COWM or LM firm, they must provide some incentive for increasing output. Examples of what will not work in this regard are fixed income constraints of either of the following two forms:

(7.37) $$\frac{\mu(R-\rho k)}{N} \leq M, \quad \text{or} \quad \mu(R-\rho k) \leq M,$$

where M is a fixed positive number. A formal analysis easily shows[22] that sub-jecting labor's utility maximization to either of these income constraints is counterproductive in the COWM and LM firms. Both workers' utility and output will be reduced whenever these constraints are binding. This is because, as M is de-creased in (7.37), the prospect of earning less decreases worker effort x. More-over, increases in N to offset this would further reduce the typical worker's income by reducing his share ($\mu/N$) of V. Thus, absolute income constraints provide the wrong incentives for labor.

To provide incentives for increased output, consider income constraints of the following form:

(7.38) $$\frac{\mu(R-\rho k)}{N} \leq mR;$$

(7.39) $$\mu(R-\rho k) \leq mR,$$

where $0 < m \leq 1$. These restrictions on worker's income and total labor income are relaxed as output increases, with obvious intended effects.

Consider (7.38) first, for the COWM firm. We continue to assume, unless otherwise noted, that (7.8) is not an effective constraint for the COWM firm. The capital manager's problem then yields the optimality condition $(7.22)_K$ which we reproduce here as

(7.40) $$\alpha R = \rho K.$$

Assuming a positive tax rate $1-\mu$ for the moment, labor's problem is,

$$(7.41) \qquad \text{Max } \frac{\mu(R-\rho K)}{N} - E(x)$$

subject to (7.38). This leads to the following first-order conditions ($\lambda \geq 0$ being the multiplier for (7.38)):

$$(7.42) \qquad (N\lambda m + (1-\lambda)\mu)bR = N\gamma Cx^{\gamma};$$

$$(7.43) \qquad (1-\lambda)\mu\left(\frac{R-\rho K}{N}\right) = (N\lambda m + (1-\lambda)\mu)R \frac{f'(N)}{f(N)} .$$

These, together with (7.40), provide the equilibrium conditions for the case at hand.

In Kleindorfer and Sertel (1979c) we solve the system (7.40), (7.42)-(7.43) in terms of $\lambda$. We show that as the regulatory constraint becomes more restrictive ($\lambda$ increases), N increases. We then study whether some regulation of the form (7.38) is efficient by examining whether welfare $W(\lambda)$ increases as the constraint (7.38) just becomes effective (i.e., whether $dW/d\lambda > 0$ at $\lambda = 0^+$). The results of this analysis are as follows.

As either $\epsilon$ approaches unity, $\alpha$ becomes large, or as $\gamma$ becomes small, $dR(\lambda)/d\lambda$ and $dW(\lambda)/d\lambda$ are positive near $\lambda = 0^+$, and therefore (some) regulation of the form (7.38) is efficient in these cases. The rationale for these results is as follows. The COWM solution $\underline{N} = N\left(\frac{1}{1-\alpha}\right)$ is an increasing function of $\alpha$ (since $N(t)$ in (7.14) is increasing in t) and the WM solution $\overline{N} = N\left(\frac{\gamma}{b}\right)$ is increasing in $\gamma/b$. Thus, as $\gamma$ becomes large, b becomes small (i.e., $\epsilon$ becomes small), or $\alpha$ becomes small, the difference between the COWM employment level and the welfare-optimal level becomes large. In these cases the regulatory constraint (7.38) provides increased revenue, output and welfare in the COWM firm, when regulation is not too tight. We also show that such regulation always ceases to be efficient

before $N(\lambda)=\overline{N}$, so that the optimal regulated COWM firm will have a smaller labor force (and capital input) than the welfare-optimal firm. Similar results hold for the LM firm.

As a final matter, suppose income regulation is imposed through a constraint of the form (7.39). Then if the capital manager sets K according to (7.40) as usual, (7.39) would, if binding, imply $\mu(1-\alpha) = m$. If we reduce m below $\mu(1-\alpha)$, clearly no feasible solution will obtain since, for $m<\mu(1-\alpha)$, (7.40) would imply $\mu(R-\rho K)/N<0$, violating the requirement that $U = \mu(R-\rho K)/N - E(x) \geq \hat{U}$.

Thus, imposing regulation of the form (7.39) on the COWM firm (or on the LM firm) would require that the capital manager pay attention to the competitive utility-level constraint $U \geq \hat{U}$ in choosing K. He would then react to any fixed N and x by maximizing W subject to $U \geq \hat{U}$, while labor's adjustment process to capital would involve maximizing U subject to (7.39). Given the complexity of this procedure and the informational problems involved, one can safely exclude it from further consideration.

### 4.2 Price and Tax Regulation

Taking stock of results thus far, we see that institutional regulation through a properly motivated capital manager improves efficiency of the LM firm. This can be further improved in certain cases by constraining income per worker not to exceed a specified fraction of total revenue. We now consider whether the performance of the COWM or LM firm can be improved through price or tax regulation.

Considering tax regulation first, we have already noted that taxing workers' incomes (decreasing $\mu$ in the above model) decreases overall welfare, essentially because workers react to such taxes by decreasing revenue and consumers' surplus at a faster rate than the accumulated rax revenues generated. Since the

behavior of the COPM firm is identical to that of the LM firm (see footnote 19), but with an additional "tax" on workers' income in the form of residual profits, the COPM firm is inefficient unless such profits are zero and all of V is distributed as labor income.

Regarding lump-sum taxes, these can be expected to improve the efficiency of the COWM or LM firm by giving labor an incentive to increase its size in order to spread the tax burden. Incorporating lump-sum taxes in the previous analysis amounts to specifying labor's problem, in place of (7.19), as maximizing

$$(7.44) \qquad U = \frac{(R-\rho K-T)}{N} - Cx^{\gamma},$$

where T is the tax imposed. The capital manager in the COWM firm continues to maximize W in (7.16), independent of T. The equilibrium conditions for these problems are then (7.40) and

$$(7.45) \qquad bR = NC\gamma x^{\gamma};$$

$$(7.46) \qquad \frac{R-\rho K-T}{N} = R \frac{f'(N)}{f(N)} .$$

Assuming $T<(1-\alpha)R$, so that positive value-added results when the capital manager sets $\rho K=\alpha R$, we see that

$$(7.47) \qquad \frac{R}{R(1-\alpha)-T} > \frac{1}{1-\alpha} .$$

Thus, from (7.46), $0<T<(1-\alpha)R$ implies $N(T)>\underline{N}$ by (7.22) and (7.27).

It is easy to show that lump-sum tax regulation can lead to efficiency increases by providing an incentive to increase N to the welfare-optimal level $\overline{N}$.

$$(7.48) \qquad T^* = (1-\alpha-\frac{b}{\gamma})R^*,$$

where

(7.49)
$$R^* = \left(\frac{b}{\beta}\right)^{\frac{b}{\gamma(1-\alpha)-b}} \bar{R},$$

with $\bar{R}$ the welfare-otpimal revenue. We show in Kleindorfer and Sertel (1979c) that imposing $T^*$ as a lump-sum tax will result in the regulated COWM firm setting $N=\bar{N}$, the WM employment level, with $R=R^*$ as the resulting revenue. As expected, this results in increases in both welfare and output in the COWM firm relative to the unregulated case $T=0$. The same line of reasoning establishes the efficiency of lump-sum taxes for the LM firm (with $T^* = (1-a-b/\gamma)R^*$ now in (7.48)).

Finally, let us briefly consider price regulation for the COWM firm. The potential benefits of price regulation in increasing output are clear. However, there is a tradeoff involved between these potential gains and the reduction in productivity incentives for labor resulting from decreasing their earning possibilities through price ceilings. There are also problems with the short-run response of the COWM and LM firms to price regulation.

To formulate the problem, we assume that the capital manager in the COWM firm chooses not only K (as in (7.40)) but also price $\hat{P}$ so as to maximize W in (7.16). Labor takes $\hat{P}$ and K as given and solves the following problem (compare with (7.19)):

(7.50)
$$\text{Max } \frac{\hat{P}K^{\alpha}x^{\beta}e(N)-\rho K}{N} - Cx^{\gamma},$$

subject to:

(7.51)
$$Y = K^{\alpha}x^{\beta}e(N) \leq \left(\frac{\hat{P}}{A}\right)^{-\epsilon}.$$

The maximand in (7.50) is $(PY-K)/N-E(x)$; the constraint (7.51) requires no excess supply, but it does permit excess demand. In the event of excess demand, we assume

rationing of demand in order of willingness-to-pay.[23] If excess demand obtains the capital manager has a problem in the short-run. If he increases price to clear the market (keeping capital fixed), then labor will tend to reduce output even further.[24] If he reduces prices, then whether labor increases output more than the demand increase depends on the demand elasticity among other things.

We study (7.50)-(7.51) in detail in Kleindorfer and Sertel (1979c) where we show that price regulation is efficient. Here we simply present the result of this analysis. First, one shows that just at the price $\hat{P}$ where (7.51) becomes binding, the equilibrium employment level $N(\hat{P})$ of the price-regulated COWM firm exceeds that of the unregulated COWM firm. In fact, if $1-\alpha<\beta/\gamma$, $N(\hat{P})$ will exceed the WM solution $\bar{N}$ as (7.51) just becomes effective. Next, one shows that as the constraint (7.51) is tightened (i.e., $\hat{P}$ is increased), the resulting employment level decreases at long-run equilibrium.

These facts motivate the basic strategy for determining an efficient price. When $1-\alpha\geq\beta/\gamma$, this turns out to be a just market clearing price in (7.51), which is associated with an employment level between that of the COWM and WM firms. If $1-\alpha<\beta/\gamma$, then price should be somewhat higher than the unconstrained equilibrium solution to (7.50)-(7.51) and (7.40), and set so that the equilibrium employment level does not exceed the WM solution $\bar{N}$.

In summary, price regulation can improve welfare and output for the LM and COWM firm in the long run by inducing labor to act as a price taker. However, achieving this may require a delicate balancing act to avoid short-run excess demand and to obtain a stable regulatory response. It is interesting to note in this regard that if decreases in employment level can only be accomplished in the long-run, then the above price-regulated COWM firm will respond normally to price increases in the short-run. This is so since, for fixed N and K, the solution to

(7.50)-(7.51) will entail increases in average input per worker (and therefore output) in response to price increases.

## 5.  CONCLUDING REMARKS

This paper has two central themes:  the comparative analysis of alternative institutional forms of labor influence in monopolies; and the design of regulatory mechanisms for improving the welfare efficiency of such firms.

Concerning the comparative analysis of different firm types, labor-managed  and codetermined firms have two basic problems:  underemployment and perverse short-run adjustment to price changes of output and long-run inputs. In addition, labor-managed firms may undervalue investment projects and retained earnings relative to efficient market levels.  On the positive side, being the partial recipient of residual profits in the firm improves labor productivity. The policy implications of this analysis are simply stated.  If overemployment or low productivity are central problems, then increasing labor's influence in the firm, with concommitant incentives, is a possible cure.  Just how well this cure is likely to work relative to a traditional capitalist-managed firm depends, inter alia, on the income elasticity of workers' effort (how well they will respond to productivity incentives) and the price elasticity of demand (how strongly the market reinforces increases in output resulting from improved productivity).

Regarding regulation, lump-sum taxes, and income and price regulation can improve the efficiency of labor-managed and codetermined firms.  More direct regulation in specifying acceptable levels of capital input and employment will naturally also improve efficiency, gross of the transactions costs involved.  In some instances, however, the perverse short-run adjustment of such firms to

factor and output price changes may lead to instabilities in the regulatory process.

We have viewed firm participants as being involved in a noncooperative game with firm designers and regulators, where design and regulatory parameters are constrained by alternative earning possibilities offered to firm participants in the market place. This analysis has underlined the importance, in a static setting, of the interactions between internal incentives and adjustment, market constraints and efficient regulation. A promising area for future research is to extend this approach to a dynamic setting to account for seniority and human capital formation in the firm and to explicitly analyze the short-run and long-run response of labor-managed and codetermined firms to various forms of regulation.

## FOOTNOTES

1. See Brachet (1978), Farthmann (1977), HMSO (1978), I.D.E. (1979),
Nutzinger (1979), Oakeshott (1978), and Sertel et al. (1978) for dis-
cussions of the current situation in this regard in Europe.

2. See Crew and Kleindorfer (1979), Chapter 9, for elaboration of the
following general discussion.

3. There are a host of interesting informational issues associated with
implementing wage and sharing incentives. These relate to the fact that
wages require inputs to be measured while sharing requires that value-added
be measured. Comparing these two classes of incentives is therefore also a
matter of assessing the differences in administration and monitoring costs
associated with them. See Kleindorfer and Sertel (1979b) for discussion.

4. See Finsinger (1979) for a thorough discussion of this welfare function.
Essentially, if one assumes that not only the producers and workers exhibit
preferences which are separable in money and other goods, but also consumers,
then (2.6) represents the result of simply summing all involved agents'
utility functions. The usual optimality properties then follow for the
solution to maximizing (2.6).

5. See Ward (1958), Domar (1966), Vanek (1970), and Meade (1972), 1974). Vanek (1970),
Markusen (1975), Furubotn (1976), Bonin (1977), Kleindorfer and Sertel
(1979a) and Ireland (1979) include worker effort (x) in their analysis as
well.

6. See Ward (1958), Meade (1974), and Gal-or et al. (1978). These results hold whether the firm is a price-taker or a monopolist in its output market.

7. See Ireland (1979) on the first point and Robinson (1967) on the second.

8. We return to an analysis of the effects of varying shares $\mu$ (where $1-\mu$ can be viewed as a tax rate) on the LM firm in Section 3 below. One might also consider an LM firm with wage incentives. Assuming cooperative behavior, the LM firm is indifferent between wage and sharing incentives since the entire firm's surplus is distributed as workers income in either case.

9. Note that the formulation (7.7)-(7.8) assumes that the CM firm designer knows the worker effort function $E(x)$ and plans accordingly. We do not treat supervision and monitoring costs explicitly here, i.e., the costs of obtaining effort x from labor, compatible with the function $E(x)$. See Ireland (1979) for a more explicit treatment of these costs in the LM and CM firms. See Kleindorfer and Sertel (1979a, b) for an analysis of the case where the CM firm uses sharing incentives. Neglecting monitoring costs, as we do here, the CM firm always prefers wage incentives to sharing incentives.

10. Further details on these matters may be found in the more extensive, original version of this paper, Kleindorfer and Sertel (1979c).

11. See Meade (1972, 1974) and Ireland (1979). The latter author presents a framework similar to that used here, where worker effort is included in the analysis, albeit in the symmetric form where $F(K,x,N) = \bar{F}(K,N,x)$.

12. See also Gal-or et al. (1978) and Oakeshott (1978) for a discussion of the mechanics of entry and severance fees, and Ireland and Law (1978) for a similar idea.

13. See Furubotn and Pejovich (1970), Jensen and Meckling (1977) and Ireland (1979).

14. See McCain (1977), Sertel (1978) and Sertel and Steinherr (1979) for a discussion and critique of the Furubotn-Pejovich results.

15. Second, the typical manner in which entry fees are collected is to assume that workers own the firm in question. Entry fees go into retained earnings of the firm in which each worker-owned accrues shares over time (see Oakeshott (1978)). This is an interesting case, but one which entails a number of problems, especially for state enterprises, in collecting and vesting such entry fees through the ownership structure.

16. There is a problem with (7.15) in that the function f there becomes negative. As is clear, however, only the domain of f which is positive is of interest, so a truncated version of (7.15) will serve as an appropriate example. When $c_2 \geq 1$ in (7.15), f is convex and thereafter concave, reaching a maximum at some $N^* > 0$. These are essentially the properties required for $N(k)$ to have the desired properties (i)-(ii) above.

17. Elaboration and proofs of these points can be found in Kleindorfer and Sertel (1979c). A further institutional form studied in that paper is the COWM firm in which the capital manager sets not only K but also N. As expected, this leads to further welfare improvements in the COWM case.

18. See Kleindorfer and Sertel (1979c) for a formal derivation.

19. The only difference between the LM and COPM firms is in the determination of the sharing rate $\mu$. For the COPM case, this would be determined, as in Kleindorfer and Sertel (1979a), so as to maximize profit, whereas $\mu$ might be set in the LM case to maximize welfare. In either case, we know from section 3.4 that welfare will suffer unless $\mu=1$ and residual profit and taxes levied are zero.

20. $\bar{N}$ is bounded if f has a finite maximum $N^*$, since there $f'(N^*)=0$. By (7.14) we see that $N(k)$ will be less than $N^*$ for any k.

21. Note that the welfare function W includes producers' surplus and government tax revenues raised from the operations of the firm in question.

22. See Kleindorfer and Sertel (1979c) for details.

23. See Crew and Kleindorfer (1979) for a discussion of alternative rationing policies and their implications for welfare measurement and pricing. The easiest assumption to work with is rationing in order of highest willingness-to-pay first, since in this case the welfare function (7.5) remains a valid measure of aggregate net benefits under conditions of excess demand.

24. See Ward (1958) for an analysis of a two-factor model of the LM firm for conditions guaranteeing this.

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